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A Decision Support Tool for Appointment Scheduling to Reduce Patient No-Show Rate in an Outpatient Psychiatric Clinic

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Table of Contents

Abstract:

The Walker Family Clinic in the Psychiatric Research Institute at the University of Arkansas for Medical Sciences in Little Rock, Arkansas provides general and specialty mental health and substance abuse services for adolescents and adults. As there is an increasing need for health services at the clinic, the current capacity may not be able to meet all demands. Patients may wait a long time before receiving care due to inefficiencies in the current system. Also, based on data collected from August 1, 2013 to November 26, 2014, the average daily no-show rate was 13.9% and the maximum daily no-show rate was 50%. No-shows have numerous adverse effects on healthcare clinics, such as financial costs. Both open-access and overbooking have been proven to help mitigate the adverse effects of no-shows at various clinics. In order to help combat the system inefficiencies at the WFC by reducing the wait time to first appointment and improving no-show rates, a decision support tool is proposed to help the WFC implement open-access scheduling in coordination with the existing method of fixed scheduling, as well as strategic overbooking practices. To achieve this goal, conclusions drawn about risk factors for no-shows from statistical analysis on patient appointment data were used to create a scenario tree and rank the scenarios by highest number of no-shows and highest probability of no-shows. Using Pareto analyses on these two lists, the lists were compared, and the scenarios that fit both lists were deemed "high risk of no-show," with the remaining scenarios categorized as "low risk of no-show." Using these separate groups of scenarios, additional statistical tests were conducted on the remaining factors initially found to be insignificant to no-show rates to determine if certain levels of these factors are more prominent in one of the groups of scenarios than another. In addition, a decision support tool was developed in Microsoft

Excel that inputs the risk factors, finds the matching scenario in one of the two lists, and makes a recommendation of whether to schedule the patient using open-access scheduling/overbooking or the existing method of fixed scheduling.

1. Introduction

The Walker Family Clinic (WFC) in the Psychiatric Research Institute (PRI) at the University of Arkansas for Medical Sciences (UAMS) provides general and specialty mental health and substance abuse services for adolescents and adults, and it is currently facing problems with no-shows. Based on data collected from August 1, 2013 to November 26, 2014, the average daily no-show rate was 13.9% and the maximum daily no-show rate was 50%. In addition, increasing demand for mental health services at the clinic coupled with its current capacity have created a significant delay for patients in receiving care. To combat these issues, the clinic currently uses methods of double-booking certain patients during scheduling. This way, if one patient does not show up for his/her appointment, there may be another patient scheduled at the same time who can see the care provider, and that time slot is not wasted. If a provider is double booked for a certain time slot and both patients show up for their appointments, another care provider fills in for the patient whose appointment was scheduled later so as not to get behind in the providers' schedules.

An improved or alternative solution has been suggested to help the clinic reduce the wait time to first appointment and combat no-show rates. A decision support tool, which, given a combination of factors, determines the risk that a patient will not show up for his/her appointment, may be used to strategize which appointment times to double-book. In addition, such a tool may be used to help the clinic implement open-access scheduling in coordination with the existing method of fixed scheduling, rather than double-booking. Knowing the types of appointments that pose a risk of a no-show could be beneficial to the clinic in a plethora of ways, and it may help in cutting back costs associated with no-shows.

The overall goal of this research is to develop a decision support tool to help the WFC strategically implement open-access scheduling and overbooking practices in order to reduce no-show rates and wait times to first appointment. In order to achieve this goal, my research objectives are to:

1. Identify combinations of significant factors that may lead to no-show behavior and rank these combinations based on the risk of no-show;

2. Further explore the effects levels of certain factors previously found to be insignificant may have on no-show behavior and;

3. Design and implement an Excel-based decision support tool incorporating the high and low risk scenarios that outputs scheduling recommendations.

2. Literature Review

2.1 Cost of No-Shows and Long Lead Times

The majority of patient care in the U.S. is provided by outpatient clinics (80-90%) (Centers for Medicare and Office of the Actuary Medicaid Services, 2005). For most of these clinics, patient nonattendance of appointments, or "no-show," is a significant problem (Ulmer & Troxler, 2004). There are various reasons for no-shows: changes or improvements in health conditions, other personal or work-related problems, seeking treatment elsewhere for an earlier appointment, etc. (Green & Savin, 2008). Regardless of the reason, no-shows interrupt the flow of patient care, and cause a decline in clinical productivity (Alshammari, Ali, Alshammary, & Armstrong, 1993). Furthermore, aside from administrative difficulties and disruptions of patient-provider relationships that arise due to no-shows, substantial financial factors also create major problems for many clinics

(Jones & Hedley, 1988). One study showed that only 74% of community mental health patients surveyed were satisfied with their access to services (LaGanga & Lawrence, 2007). Another study found that for a particular clinic in South Carolina, approximately 14.2% of anticipated revenue might be lost in a typical day due to no-shows (Moore, Wilson-Witherspoon, & Probst, 2001). One clinic suffered losses of over $1 million due to 14,000 no-shows in one year (LaGanga, 2011). From healthcare settings with no-show rates of 3% to healthcare settings with no-show rates of 80%, no-shows pose a significant threat to every clinic (LaGanga & Lawrence, 2007). The national level of no-show rate across various healthcare settings is 21% (Hixon, Chapman, & Nuovo, 1999). Clearly, office systems that decrease no-show rates are highly valuable to outpatient clinics in maximizing office function and lessening financial losses (Moore, Wilson-Witherspoon, & Probst, 2001).

In addition, another source of problems for many clinics is long periods of time between the date a patient is scheduled and the date of his/her appointment, known as the "lead time." This lack of timely access to patient care leads to patient dissatisfaction and financial losses, and various studies have proven that long lead time are connected to adverse outcomes. In fact, research has shown that the longer the lead time, the higher the chance of a no-show or cancellation (Liu, Ziya, & Kulkarni, 2009). This illustrates the importance of efficient scheduling and resource allocation to meeting demands in an outpatient healthcare clinic (LaGanga, 2011).

2.2 Scheduling Solutions

To combat no-shows and long lead times, many clinics practice overbooking as a means of mitigation. This method, however, comes with a tradeoff: while overbooking has

been found to significantly improve patient access to care and provider productivity, it causes an increase in patient wait times at the clinic and provider overtime (LaGanga & Lawrence, 2007). These threaten customer service and customers' perceptions of fairness, which makes the solution of overbooking somewhat controversial (LaGanga, 2011). A particular study that analyzed this tradeoff between the increase in patient access to care and the decrease in customer satisfaction caused by overbooking found that the utilization of this method is greater for clinics with larger numbers of patients, higher no-show rates, and lower service variability, but it was also concluded that positive net results might be achieved with overbooking even for clinics with high service variability (LaGanga & Lawrence, 2007).

Another method of combating issues with lead times and no-shows that is gaining popularity is implementing a different form of scheduling known as open-access scheduling. In open-access scheduling, appointments are made for the same day as the patient's phone call (Kopach et al., 2007). This type of scheduling is proven to reduce no-show rates effectively (Bundy, Randolph, Murray, Anderson, & Margolis, 2005). Patients are less likely to forget their appointments, and urgent issues can be addressed promptly. In fact, some practices that have implemented open-access scheduling have reduced their no-show rates to near zero (Kopach et al., 2007).

2.3 Factors Influencing No-Shows

In order to estimate the probability of a no-show, significant factors about patient and appointment characteristics that influence whether or not a person shows up for his/her appointment must be identified. The factors found in the existing literature as risk

factors for no-show at psychiatric clinics include, but are not limited to, age, race (Goldman, Freidin, Cook, Eigner, & Grich, 1982), whether the patient is a new patient or a follow up patient, the severity of mental disorder (Killaspy, Banerjee, King, & Lloyd, 2000), the patient's insurance type (Guse, Richardson, Carle, & Schmidt, 2003), visit type, type of care provider, lead-time to service (Freidline, 2007), patient's history of no-shows, and time of the appointment (Daggy et al., 2010).

3. Methods

3.1 Overview of Processes at WFC

The first step in this project was to understand better the processes associated with the WFC. To do this, visits to the WFC at UAMS were conducted. Staff and care providers at the clinic were interviewed to understand and define the processes involved with scheduling and seeing patients, as well as to receive and document input on inefficiencies and frustrations with the system. Using these information, a process map for the clinic was created that encompassed all processes from the time a patient calls to schedule an appointment, to the end of their appointment. This process map can be seen in Figure 1 below.

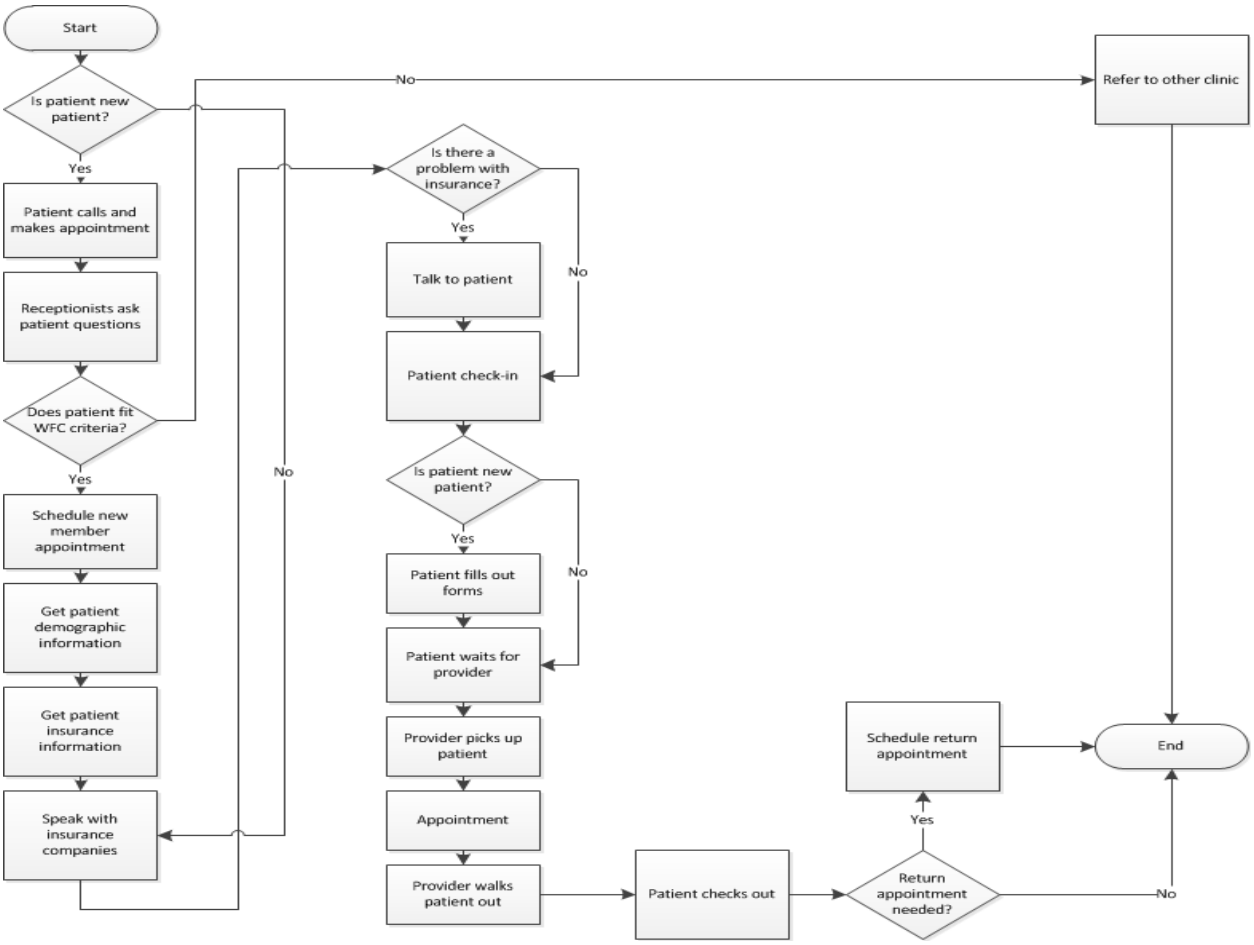

Figure 1. Process map of the WFC

While documenting this process of scheduling and seeing patients, it became clear that the clinic's biggest efficiency issues centered on scheduling. While the general process involved with scheduling new patients versus returning patients is virtually the same, different persons are responsible for each type of scheduling. Appointment scheduling for returning patients generally takes place right after completion of a previous appointment at the front desk. After the patient's appointment is completed, the provider walks them out of the room and back to the front desk where they schedule his/her next appointment together with one of the two staff at the front desk. The provider simply tells the staff at the front desk when they would like to see the patient again, and the staff finds the soonest

time slot available in the provider's schedule after the specified amount of time. The clinic does not overbook for returning patients. Conversely, new patients typically call to schedule their first appointment. One of the three receptionists working in the call room will answer the patient's call and ask him/her a series of questions to ensure that the patient fits the criteria of patients seen at the WFC. If he/she does not, the receptionist refers the patient to another clinic, and if he/she does, the receptionist schedules him/her in the soonest available time slot for a new patient appointment. New patient appointments are where the clinic practices overbooking. Each time slot can hold two new patient appointments. Additionally, for both new and returning patients, appointments are scheduled on the hour or half hour.

In addition, frustrations expressed by providers and staff members of the WFC heard in interviews were also documented. Many staff expressed issues with the fact that the clinic was receiving too many patients and did not have enough resources to support the demand. For example, when these interviews were being held in early June of 2014, appointments were currently being scheduled for mid to late August. Providers and staff members alike saw this as an excessive amount of time for patients to wait to receive care. Furthermore, due to the high demand and lack of resources, the clinic was only able to offer medicine appointments to patients and could not provide therapy appointments at the time.

3.2 Scenario Trees and Scheduling Recommendations

To understand the types of appointments that lead to high risks of no-show, it was first important to analyze various factors affecting no-shows. Patient appointment data

from August 2013 to November 2014 was provided by the WFC that included 24,334 appointments and 3,699 patients. This data included appointment date, appointment time, ICD-9 code, a patient ID number, visit type, appointment length, date scheduled, and appointment status (if the appointment was completed or not). Some appointment records were removed from the data, such as those with scheduled appointment dates after the actual appointment date (with negative lead times) and those with appointment times after 5 PM (special arrangements), when the clinic closes. After cleaning of the data to ensure reliable results, this data was split into two separate data sets: new patients (4,092 observations) and returning patients (20,008 observations). A new patient was classified as a patient who was scheduled for a new patient appointment or a patient who had no previous appointments in the data set. A returning patient was a patient who had at least one previous appointment in the data set.

In preliminary studies, certain factors were selected to test for significance for both the new patient and returning patient data sets using regression models. Selection of these factors was guided by the available data and previous studies found in literature presented in Section 2.3 (Wang, 2015). Two scenario trees (one for new patients and one for returning patients) were then crafted using all possible combinations of the levels of these factors found to be significant.

Once these scenarios were listed out, the probability of a no-show was calculated using the existing data for each scenario. A Pareto analysis was then conducted to determine the Pareto point of no-show probabilities, which listed the scenarios that accounted for about 80% of the sum of the no-show probabilities. Another Pareto analysis was conducted to determine the Pareto point of the number of no-shows for which each

scenario was responsible. This showed the scenarios responsible for about 80% of the total no-shows in the data. It was important to factor in both of these lists of scenarios because some of the no-show probabilities were high due to a small number of appointments for that scenario, and some of the no-show counts were high simply because there were a large number of appointments for that scenario; thus, these two lists were compared, and scenarios that were found on both lists were combined into a single list of scenarios representing high risk of no-show because they were found to have both a high probability of no-show and a high number of no-shows in the past. The other scenarios as well as the remaining scenarios that did not make the two Pareto lists were then combined into a single group representing low risk of no-show. A recommendation for scheduling can be given based on these lists. If an appointment matches a scenario that falls under the list of high risk of no-show, then overbooking or open-access scheduling may be recommended, and if an appointment matches a scenario that falls under the list of low risk of no-show, then the regular fixed scheduling may be recommended.

3.3 Identify Differences of Insignificant Factors Between Two Populations

When scheduling staff members at the WFC were interviewed about no-shows, many seemed surprised that certain factors did not show up as significant in the regression model. For example, many expressed beliefs that appointments scheduled early in the morning (7 and 8 AM) resulted in no-shows more often than those scheduled at other times, that appointments scheduled on Mondays and Fridays resulted in more no-shows than the other days of the week, and that patients with Medicaid and Medicare insurance plans were more likely to be no-shows than those with other types of insurance. These

theories were tested for both new and returning patients using the data from the WFC sorted into the high risk and low risk populations and two proportion hypothesis testing.

For the early morning appointments, the percentage of appointments at 7 AM and 8 AM in the high risk group of scenarios over the total number of appointments in the high risk group of scenarios (P_1) was compared to the percentage of appointments at 7 AM and 8 AM in the low risk group of scenarios over the total number of appointments in the low risk group of scenarios (P_2).

For the days of the week for the appointment, the percentage of appointments on Mondays and Fridays in the high risk group of scenarios over the total number of appointments in the high risk group of scenarios (P_1) was compared to the percentage of appointments on Mondays and Fridays in the low risk group of scenarios over the total number of appointments in the low risk group of scenarios (P_2).

Finally, for the patient insurance type, the percentage of appointments with patients who have Medicaid or Medicare in the high risk group of scenarios over the total number of appointments in the high risk group of scenarios (P_1) was compared to the percentage of appointments with patients who have Medicaid or Medicare in the low risk group of scenarios over the total number of appointments in the low risk group of scenarios (P_2). The null and alternative hypotheses for each of the three experiments were as follows:

$$H_0: P_1 \leq P_2$$

$$H_1: P_1 > P_2$$

The null states that the percentage of each case in the high risk of no-show group of scenarios is less than or equal to the percentage of each case in the low risk of no-show

group of scenarios, and the alternative states that these percentages in the high risk group are greater than they are in the low risk group. All of these tests were one-tailed.

3.4 Develop Decision Support Tool

A decision support tool was created in Microsoft Excel that takes user input about a patient's appointment and outputs a recommendation for scheduling using the VBA programming language. The lists of high and low risks of no-show generated from the scenario trees and Pareto analyses were used to make this recommendation.

The complete code used for this program can be found in Appendix C. The user, which is whoever is scheduling the patient, is taken through a series of user forms where he/she inputs whether the patient is a new or returning patient, the patient's ICD-9, the appointment date and the date the appointment is being scheduled, and for returning patients, and the appointment type. Whichever inputs are selected in the ICD-9 and Visit Type user forms are stored as string variables, and both dates input into the dates user form are stored as date variables. In a sub titled "NewPatientVariables," the ICD-9 variable and the appointment date variable are converted to one of the levels of the factors used on the scenario tree. In a sub titled "ReturningPatientVariables," both date variables are used to find the lead time, which is then converted, along with the ICD-9 variable and visit type variable, to one of the levels of the factors used on the returning patient scenario tree.

Once all variables have been defined as levels listed on the scenario trees, in either the sub "NewPatients" or "ReturningPatients," the recommendation is determined based on the combination of levels and which category (high risk of no-show or low risk of no-show) that scenario falls under in the two separate lists. Two sheets in the workbook titled "New

Patient Scenarios" and "Returning Patient Scenarios" are hidden from the user. Both of these sheets list all the possible outcomes in each scenario tree, and if a scenario falls under the high risk of no-show category, it is marked with a "1" in the column beside the combination. Screenshots of these sheets can be seen in Figures A5 and A6 in Appendix C. In the "NewPatients" or "ReturningPatients" sub, the program loops through the rows of the corresponding hidden worksheet until it finds a match between the input variables and a scenario listed on the worksheet. Once this match is found, the program determines if it is marked with a "1" in the next column. If so, a Boolean variable called "HighNoShow" is set to "True", and if not, this variable is set to "False". In the "Start" sub, which is activated when the user presses the start button on the main menu, a recommendation for scheduling is outputted to the user in a message box. This sub calls on the NewPatients or ReturningPatients sub, and if the HighNoShow variable is equal to "True", the tool recommends overbooking or open-access scheduling. If this variable is equal to "False", the tool recommends the regular fixed scheduling.

There is also error checking throughout program. For example, if the user clicks "Next" on any user form without first selecting either an ICD-9 or visit type or entering in both dates on the Dates user form, he/she will get an error message requesting that he/she inputs this information. Additionally, if the user enters a date for when the appointment was scheduled that is later than the date of the appointment, another error message appears asking him/her to correct this. Finally, because there was no samples of appointments in the past data that had a lead time longer than 28 days, a recommendation cannot be made for an appointment with a lead time longer than 28 days; therefore, if the user inputs dates that result in a lead time of longer than 28 days, a message appears in

place of the recommendation stating that a recommendation cannot be made with that long of a lead time. The user may also click the "Cancel" button on any of the screens to immediately quit the program.

4. Data Analysis and Results

4.1 Scenario Trees and Scheduling Recommendations

The tested factors and results from the preliminary studies for new patients are summarized in Table 1 below, and the tested factors and results for from the preliminary studies for returning patients are summarized in Table 2 below, with the significant factors bolded (Wang, 2015)

Table 1. Significance of Each Predictor for New Patients

New Patients					
Factor	**DF**	**Deviance**	**Residual DF**	**Residual Deviance**	**Pr(>Chi)**
ICD-9	**32**	**47.414**	**1789**	**669.48**	**0.038915**
Insurance Plan	4	9.329	1785	660.15	0.053380
Appointment Length	12	10.495	1773	649.66	0.572644
Week Day	4	3.729	1769	645.93	0.443943
Month	**11**	**28.902**	**1758**	**617.03**	**0.002351**
Lead Time	5	3.852	1753	613.18	0.570871
Hour	10	10.087	1743	603.09	0.432931

Table 2. Significance of Each Predictor for Returning Patients

Returning Patients					
Factor	**DF**	**Deviance**	**Residual DF**	**Residual Deviance**	**Pr(>Chi)**
ICD-9	**32**	**127.86**	**20437**	**16871**	**< 0.0001**
Visit Type	**8**	**116.93**	**20429**	**16754**	**< 0.0001**
No-Show Rate	**6**	**537.02**	**20423**	**16217**	**< 0.0001**
Appointment Length	15	24.17	20408	16193	0.06226
Week Day	4	6.97	20404	16186	0.13736
Month	11	10.95	20393	16175	0.44727
Lead Time	**5**	**42.08**	**20388**	**16133**	**< 0.0001**
Hour	10	14.70	20378	16118	0.14333

For new patients, the factors significant to no-shows were ICD-9 and month, and for returning patients, the factors significant to no-show were ICD-9, appointment type, no-show rate, and lead-time (Wang, 2015). Because no-show rate is a dynamic variable that cannot easily be inputted to the decision support tool, this factor was left out of the scenario tree.

Taking these factors into account, there were 396 total scenarios possible for new patients (33 ICD-9 levels times 12 month levels) and 1,584 total scenarios possible for returning patients (33 ICD-9 levels times 8 appointment type levels times 6 lead time levels). The complete lists of all the levels within each factor can be found in Tables A1 and A2 of Appendix A.

Once these lists were generated, the Pareto analyses on both no-show probability and no-show count were conducted. Of the 396 possible scenarios for the new patient scenario tree, there were no past appointments in the data for 159 of them, and of the 1,584 possible scenarios for the returning patient scenario tree, there were no past appointments in the data for 1,187 of them. All of these scenarios were classified as low-risk of no-show by default because there was no evidence to prove that they are high-risk scenarios, and it was assumed that the likelihood of these appointments being scheduled is low because they have never been scheduled in the year and a half-worth of past data.

For the first Pareto analysis, the no-show probabilities were calculated for every scenario based on the past data. The scenarios were then ranked from highest to lowest no-show probability, and the cumulative no-show probabilities and cumulative percentages of the no-show probabilities were calculated. For new patient appointments, the 80% cumulative percentage was found to be after 41 scenarios, which is approximately

10.4% of the total new patient scenarios and approximately 17.3% of the new patients scenarios with existing past appointments. For the returning patient appointments, the 80% cumulative percentage was found to be after 95 scenarios, which is approximately 6.0% of the total returning patient scenarios and approximately 23.9% of the returning patient scenarios with existing past appointments. These calculations are summarized below in Table 3.

Table 3. No-Show Probability Pareto Analysis

	New Patients	**Returning Patients**
Number of scenarios with 80% cumulative percentage of no-show probabilities	41	95
Number of total scenarios	396	1,584
Percentage of 80% scenarios in total scenarios	10.4%	6.0%
Number of scenarios with existing past appointments	237	397
Percentage of 80% scenarios in scenarios with existing past appointments	17.3%	23.9%

For the second Pareto analysis, the no-show counts were calculated for every scenario based on the past data, and the scenarios were ranked from highest to lowest no-show count. The cumulative no-show count and cumulative percentages of no-show count were then calculated. For new patient appointments, the 80% cumulative percentage was found to be after 32 scenarios, but this percentage fell in the middle of a group of scenarios that all had the same number of no-shows; therefore, the 77% cumulative percentage was used, which was found to be after 25 scenarios. This is approximately 6.3% of the total new

patient scenarios and approximately 10.5% of the new patient scenarios with existing past appointments. For the returning patient appointments, the 80% cumulative percentage was found after to be after 26 scenarios, which is approximately 1.6% of the total returning patient scenarios and approximately 6.5% of the returning patient scenarios with existing past appointments. These calculations are summarized below in Table 4. In addition, graphical displays of the Pareto analyses for both no-show percentages and no-show counts can be found in Figures A1 – A4 of Appendix B.

Table 4. No-Show Count Pareto Analysis

	New Patients	**Returning Patients**
Number of scenarios with 80% cumulative percentage of no-show count	25	26
Number of total scenarios	396	1,584
Percentage of 80% scenarios in total scenarios	6.3%	1.6%
Number of scenarios with existing past appointments	237	397
Percentage of 80% scenarios in scenarios with existing past appointments	10.5%	6.5%

The complete lists of scenarios generated by each of these analyses along with the no-show count, no-show percentages, and number of appointments for each scenario for both new patient and returning patient appointments can be found in Tables A3-A6 of Appendix B. The highlighted scenarios in these lists are the scenarios that were found in both the no-show count and no-show probability lists. These scenarios for both new patients and returning patients can be seen below in Tables 5 and 6, respectively.

Table 5. New Patient High Risk of No-Show Scenarios

ICD-9	Month	Probability of No-Show	No-Show Count	Total Appointments
ADHD	September	0.153846154	4	26
Anxiety, Dissociative and Somatoform Disorders	August	0.143589744	28	195
Disturbance of Conduct	August	0.230769231	6	26
Episodic Mood Disorders	August	0.151624549	84	554
Episodic Mood Disorders	December	0.154761905	13	84
Episodic Mood Disorders	February	0.151898734	12	79
Schizophrenic Disorders	September	0.333333333	7	21
Symptoms, Signs, and Ill-Defined Conditions	August	0.375	3	8

Table 6. Returning Patient High Risk of No-Show Scenarios

ICD-9	Visit Type	Lead Time	Probability of No-Show	No-Show Count	Total Appointments
ADHD	Follow Up	2-3 Weeks	0.236842105	36	152
Episodic Mood Disorders	Follow Up 30 Min	2-3 Weeks	0.18583043	320	1722
Episodic Mood Disorders	Group Therapy	2-3 Weeks	0.266055046	87	327
Episodic Mood Disorders	RSPMI ReEval	2-3 Weeks	0.259259259	21	81
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	3-4 Weeks	0.186206897	27	145
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	In 1 Week	0.192307692	35	182
PTSD/Acute Stress/Trauma Related Disorders	Follow Up 30 Min	2-3 Weeks	0.217391304	35	161
PTSD/Acute Stress/Trauma Related Disorders	Group Therapy	2-3 Weeks	0.297520661	36	121
Schizophrenic Disorders	Follow Up 30 Min	2-3 Weeks	0.214876033	26	121

These scenarios comprise the new patient and returning patient groups classified as "high risk of no-show." By calculating the total number of appointments for all of these scenarios in the data, it was concluded that this population of appointments encompasses approximately 24% of the total number of past appointments in the new patient data set and approximately 15% of the total number of past appointments in the returning patient data set. The remaining scenarios of appointments for both new and returning patients were combined into the groups classified as "low risk of no-show"; thus, overbooking or open-access scheduling would be recommended for 24% of new patient appointments and 15% of returning patient appointments.

4.2 Identify Differences of Insignificant Factors Between Two Populations

For the one-tailed two-proportions hypothesis tests of percent of early morning appointments in the high risk of no-show scenarios versus percent of early morning appointments in the low risk of no-show scenarios, the parameters are summarized in Table 7 below.

Table 7. Parameters for Two-Proportions Tests for Early Morning Appointments

		Number of Appointments at 7 or 8 AM	Total Number of Appointments	Percentage
New Patients	High Risk of No-Show	114	993	0.114804
	Low Risk of No-Show	574	3099	0.185221
Returning Patients	High Risk of No-Show	301	3012	0.099934

	Low Risk of No-Show	1359	16996	0.079960

The P-Values of each of these tests are reported below in Table 8.

Table 8. P-Values of Two-Proportions Tests for Early Morning Appointments

	P-Value
New Patients	1.00
Returning Patients	< 0.0001

For new patients, because the P-Value is greater than 0.05, the null hypothesis cannot be rejected and it can be stated with 95% certainty that appointments at 7 or 8 AM are not more common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows. In fact, further testing proved that for new patients, appointments at 7 or 8 AM are less common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows. As for returning patients, the P-Value is less than 0.05; thus, the null hypothesis can be rejected and it can be concluded with 95% certainty that for returning patients, appointments at 7 or 8 AM are more common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows.

For the one-tailed two-proportions hypothesis tests of percent of Monday and Friday appointments in the high risk of no-show scenarios versus percent of Monday and Friday appointments in the low risk of no-show scenarios, the parameters are summarized in Table 9 below.

Table 9. Parameters for Two-Proportions Tests for Monday/Friday Appointments

		Number of Appointments on Monday or Friday	Total Number of Appointments	Percentage
New Patients	High Risk of No-Show	363	993	0.365559
	Low Risk of No-Show	1024	3099	0.330429
Returning Patients	High Risk of No-Show	1047	3012	0.347610
	Low Risk of No-Show	5874	16996	0.345611

The P-Values of each of these tests are reported below in Table 10.

Table 10. P-Values of Two-Proportions Tests for Monday/Friday Appointments

	P-Value
New Patients	0.023
Returning Patients	0.423

For new patients, because the P-Value is less than 0.05, the null hypothesis can be rejected and it can be concluded with 95% certainty that appointments on Mondays and Fridays are more common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows. For returning patients, the P-Value is greater than 0.05. The null hypothesis then cannot be rejected and it can be stated with 95% certainty that

appointments on Mondays and Fridays are not more common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows.

Lastly, for the one-tailed two-proportions hypothesis tests of percent of appointments with patients whose insurance plan is Medicaid or Medicare in the high risk of no-show scenarios versus the percent of appointments with patients whose insurance plan is Medicaid or Medicare in the low risk of no-show scenarios, the parameters are summarized in Table 11 below.

Table 11. Parameters for Two-Proportions Tests for Medicaid/Medicare Appointments

		Number of Appointments with patients with Medicaid or Medicare	Total Number of Appointments	Percentage
New Patients	High Risk of No-Show	470	993	0.473313
	Low Risk of No-Show	1411	3099	0.455308
Returning Patients	High Risk of No-Show	1675	3012	0.556109
	Low Risk of No-Show	7379	16996	0.434161

The P-values of each of these tests are reported below in Table 12.

Table 12. P-Values of Two-Proportions Tests for Medicaid/Medicare Appointments

	P-Value
New Patients	0.170
Returning Patients	< 0.0001

For new patients, because the P-Value is greater than 0.05, the null hypothesis cannot be rejected and it can be stated with 95% certainty that appointments for patients whose insurance plans are Medicaid and Medicare are not more common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows. For returning patients, the P-Value is less than 0.05; thus, the null hypothesis can be rejected and it can be concluded with 95% certainty that for returning patients, appointments for patients whose insurance plans are Medicaid and Medicare are more common in scenarios with a high risk of no-shows than in scenarios with a low risk of no-shows.

4.3 Develop Decision Support Tool

The decision support tool's main menu is a screen that includes a "Start" button and an "Instructions" button as seen below in Figure 2.

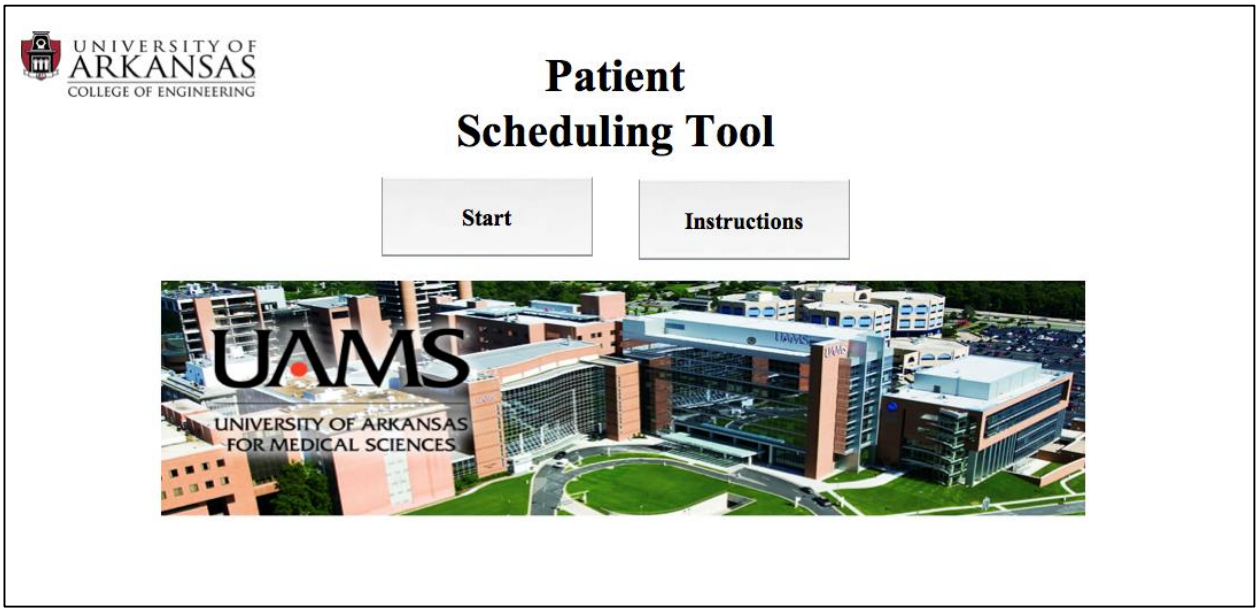

Figure 2. Decision Support Tool Home Screen

Clicking the “Instructions” button brings up a user form with a list of detailed instructions on how to use the tool. A screen shot of this can be seen below in Figure 3.

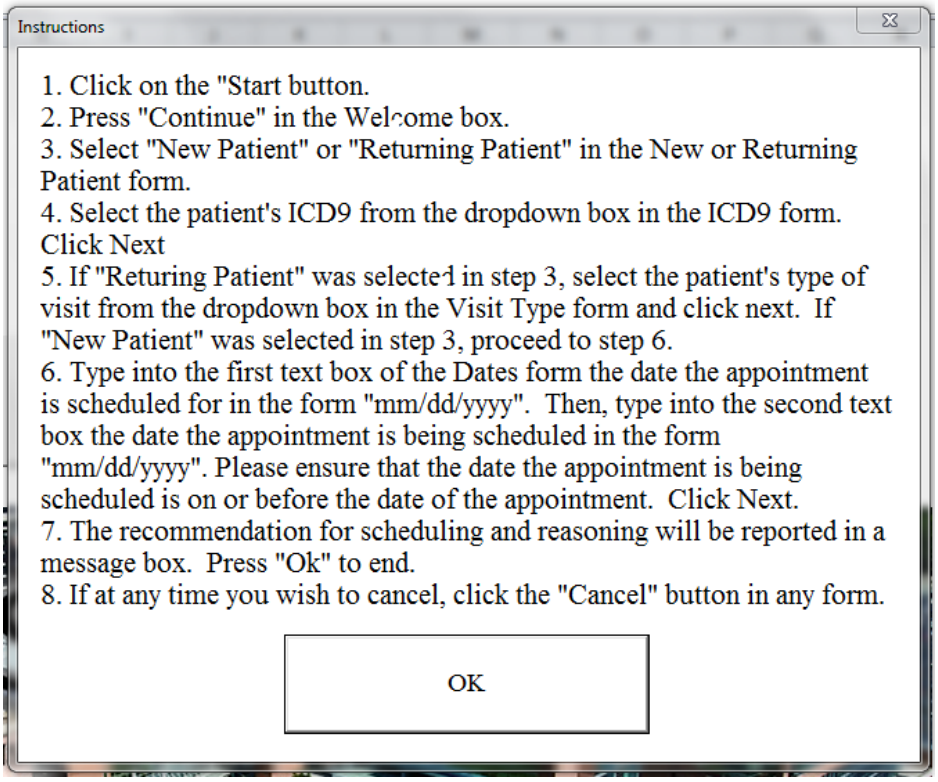

Figure 3 Instructions User Form

When the “Start” button is clicked, the user goes through a series of user forms to provide input about the patient appointment. The first user form activated is the welcome screen, and a screen shot of this is below is Figure 4.

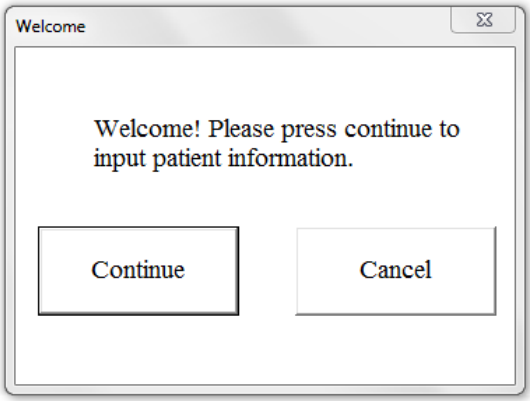

Figure 4. Welcome User Form

Once the user clicks "Continue," they are asked to select a button if the patient is a new or returning patient. This information tells the program which hidden worksheet to use to identify the risk of a no-show, and a screen shot of this can be seen below in Figure 5. Whichever the user selects, the next screen is the ICD-9 user form, which asks the user to select the patient's initial diagnosis from a drop down list of diagnoses. A screen shot of this form is below in Figure 6.

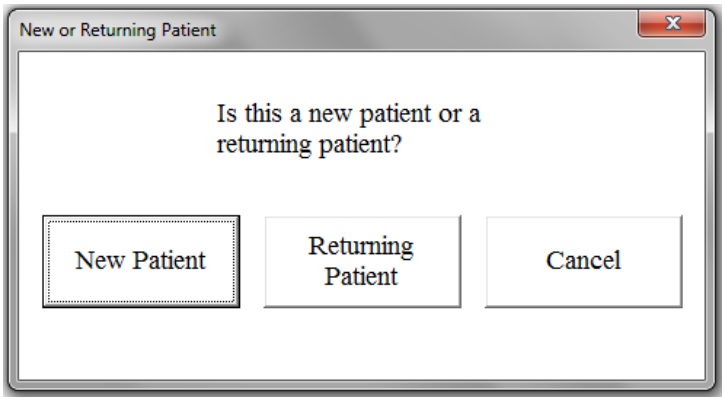

Figure 5. New or Returning Patient User Form

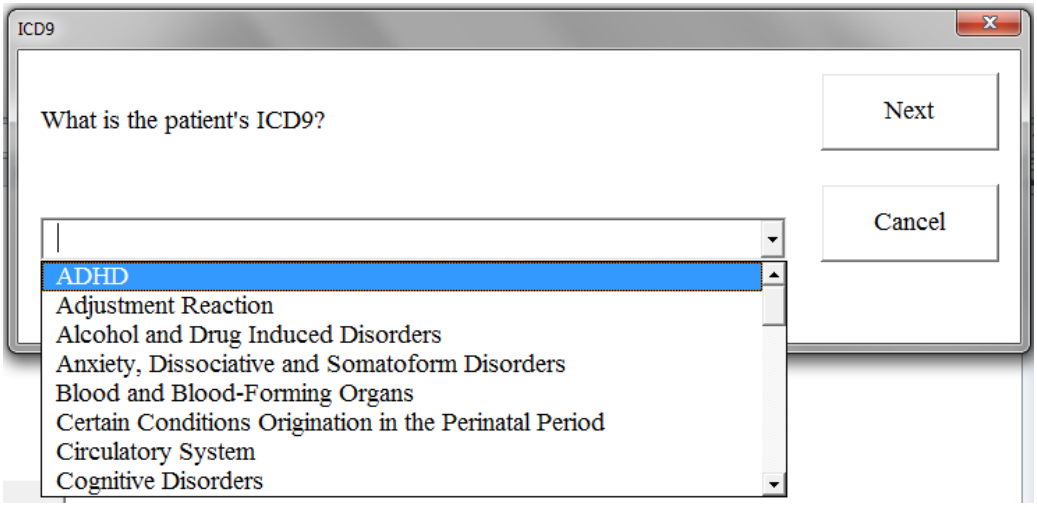

Figure 6. ICD-9 User Form

After selecting the appropriate ICD-9 and pressing "Next," the user is brought to either a user form titled "Dates" if the patient is a new patient or a user form title "Visit Type" if the patient is a returning patient. If the patient is returning and the Visit Type user form is activated, the user selects the type of visit from another drop down list and clicks the "Next" button. This brings him/her to the Dates user form that is activated when "Next" is clicked on the ICD-9 user form for a new patient. In this form, the user must input the date the appointment is scheduled for, as well as the date of the scheduling, and the date of the appointment must be later than the date of the scheduling. Both the Visit Type and the Dates forms can be seen below in Figures 7 and 8.

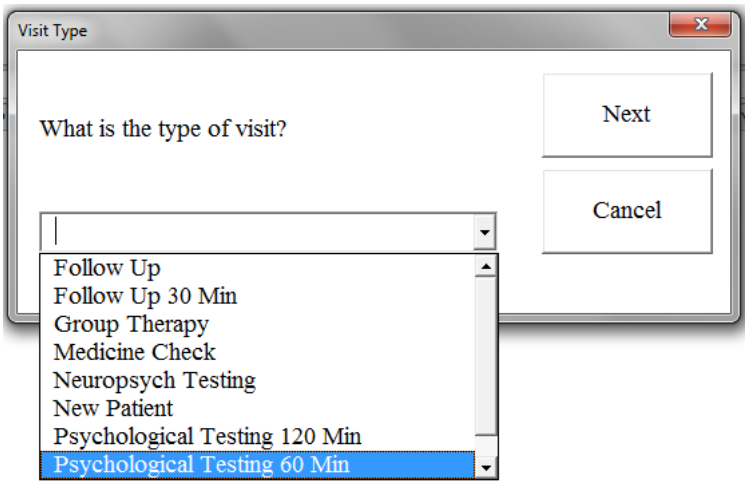

Figure 7. Visit Type User Form

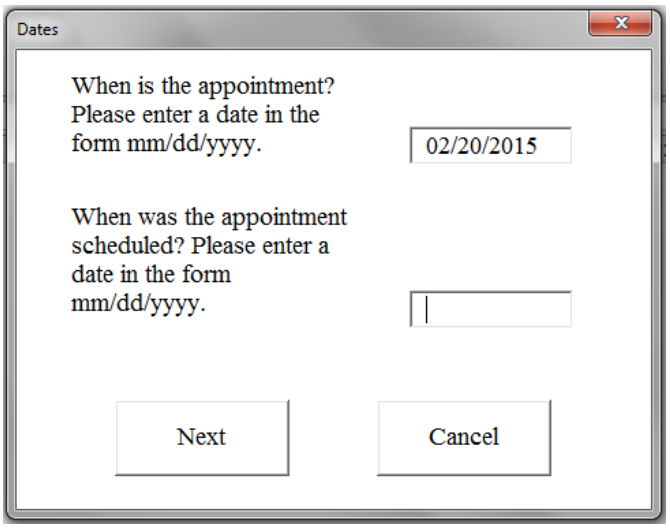

Figure 8. Dates User Form

Once this is done, the user selects "Next" one more time, and the program outputs to the user the scheduling recommendation and reasoning in a message box, and a screen shot of this is show below in Figure 9.

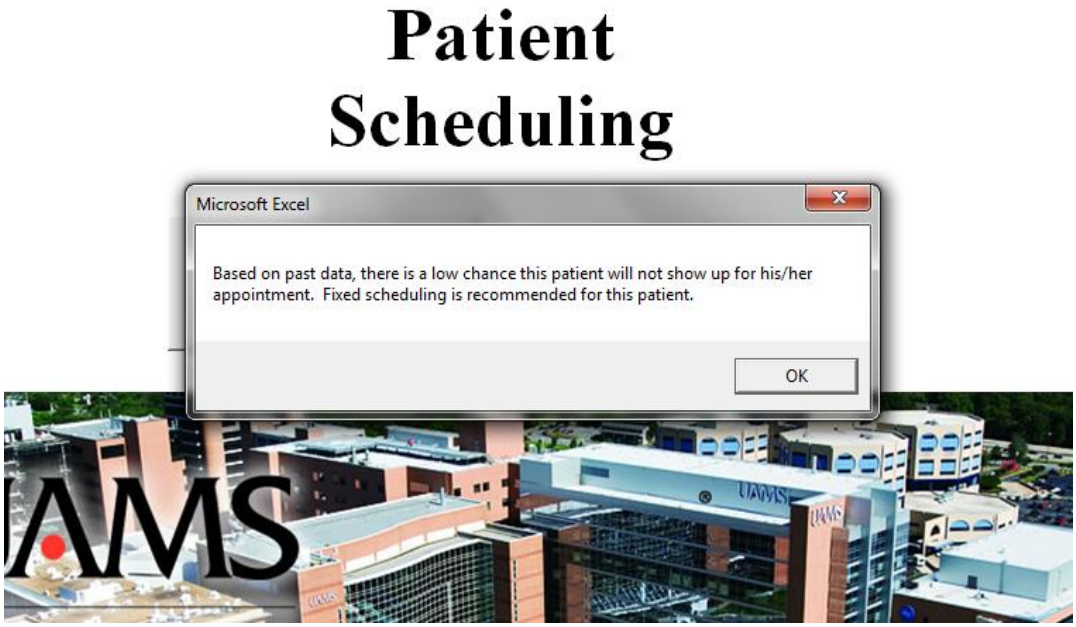

Figure 9. Recommendation Message Box

5. Conclusions, Discussion, and Future Work

There are different factors found to be significant to no-show rates for new patient and returning patient appointments. For new patients, the ICD-9, or initial diagnosis, and the month of the appointment are significant. For returning patients, the ICD-9, the visit type, and the lead time between the date the appointment was scheduled and the date of the appointment itself are significant. There are eight different combinations of ICD-9 and month of appointment that are found to be of high risk of no-show and 388 combinations of ICD-9 and month of appointment that are found to be of low risk for new patient appointments based on both the no-show percentage and no-show count of each scenario from the past data. For returning patients, there are nine different combinations of ICD-9, visit type, and lead time of appointment that are found to be of high risk of no-show and 1,575 combinations that are found to be of low risk of no-show based on both the no-show percentage and no-show count of each scenario from the past data.

Using these categories of appointment scenarios, statistical analysis of three factors initially found to be insignificant to no-show rates in the regression model lead to the following conclusions:

1. For new patients, appointments on Mondays and Fridays are more common in appointment scenarios with a high risk of no-shows.
2. For returning patients, appointments at 7 or 8 AM and appointments for patients with Medicaid or Medicare are more common in appointment scenarios with a high risk of no-shows.

These conclusions may suggest that for new patients, appointments scheduled on Mondays and Fridays have a higher risk of no-shows, but this is not the case for returning patients.

In addition, it may be suggested that for returning patients, appointments scheduled early in the morning and appointments scheduled for patients with Medicaid or Medicare are have a higher risk of no-shows, but this may not be suggested for new patients.

The tool functions properly based on the method of sorting appointments into categories of high risk and low risk of no-show; it is, however, limited in its flexibility. Only the scenarios listed as high risk based on the analysis conducted in this research may output a recommendation for alternative scheduling, and to alter which scenarios are in these high risk lists, one must manually mark which scenarios to include in the hidden worksheets. In addition, the tool cannot provide output for appointments with lead times longer than 28 days.

In future work, as more data becomes available, this model for high and low risk of no-show patients could be tested for verification and updated if needed. In addition, other methods for determining the risk of no-show could be explored, and if a more accurate model is found, this could be written into the decision support tool to improve its accuracy. Economic analysis could be conducted on the cost of a no-show versus the cost of an alternative solution such as overbooking or open-access scheduling, and this could be used to determine a no-show probability threshold for recommending the regular fixed scheduling or the alternative scheduling.

6. Acknowledgments

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Appendix A: Scenario Trees Using Significant Factors

Table A1. Levels of Significant Factors for New Patients

Factor	Level
ICD-9	ADHD
	Adjustment Reaction
	Alcohol and Drug Induced Disorders
	Anxiety, Dissociative and Somatoform Disorders
	Blood and Blood-Forming Organs
	Circulatory System
	Cognitive Disorders
	Complications of Pregnancy, Childbirth, and the Puerperium
	Congenital Anomalies
	Digestive System
	Disturbance of Conduct
	Eating Disorders
	Endocrine, Nutritional, Metabolic and Immunity Disorders
	Episodic Mood Disorders
	External Causes of Injury and Supplemental Classification
	Genitourinary System
	Injury and Poisoning
	Musculoskeletal System and Connective Tissue
	Neoplasms
	Nervous System
	Other
	Other (Behavioral Health)
	Personality Disorders
	Pervasive Developmental Disorders
	PTSD/Acute Stress/Trauma Related Disorders
	Respiratory System
	Schizophrenic Disorders
	Sexual and Gender Identity Disorders
	Specific Delays in Development
	Specific Nonpsychotic Disorders Due to Brain Damage
	Substance Use
	Symptoms, Signs, and Ill-Defined Conditions
	Tic Disorders
Month	January
	February
	March
	April
	May
	June
	July
	August
	September
	October
	November
	December

Table A2. Levels of Significant Factors for Returning Patients

Factor	Level
ICD-9	ADHD
	Adjustment Reaction
	Alcohol and Drug Induced Disorders
	Anxiety, Dissociative and Somatoform Disorders
	Blood and Blood-Forming Organs
	Certain Conditions Originating in the Perinatal Period
	Circulatory System
	Cognitive Disorders
	Complications of Pregnancy, Childbirth, and the Puerperium
	Congenital Anomalies
	Digestive System
	Disturbance of Conduct
	Eating Disorders
	Endocrine, Nutritional Metabolic and Immunity Disorders
	Episodic Mood Disorders
	Injury and Poisoning
	Mental Retardation
	Musculoskeletal System and Connective Tissue
	Neoplasms
	Nervous System
	Other
	Other (Behavioral Health)
	Personality Disorders
	Pervasive Developmental Disorders
	PTSD/Acute Stress/Trauma Related Disorders
	Respiratory System
	Schizophrenic Disorders
	Sleep Disorders
	Specific Delays in Development
	Specific Nonpsychotic Disorders Due to Brain Damage
	Substance Use
	Symptoms, Signs, and Ill-Defined Conditions
	Tic Disorders
Visit Type	Follow Up
	Follow Up 30 Min
	Group Therapy
	Medicine Check
	Neuropsych Testing
	Psychological Testing 120 Min
	Psychological Testing 60 Min
	RSPMI ReEval
Lead Time	Same Day
	Next Day
	In 1 Week
	1-2 Weeks
	2-3 Weeks
	3-4 Weeks

Appendix B: Pareto Analyses

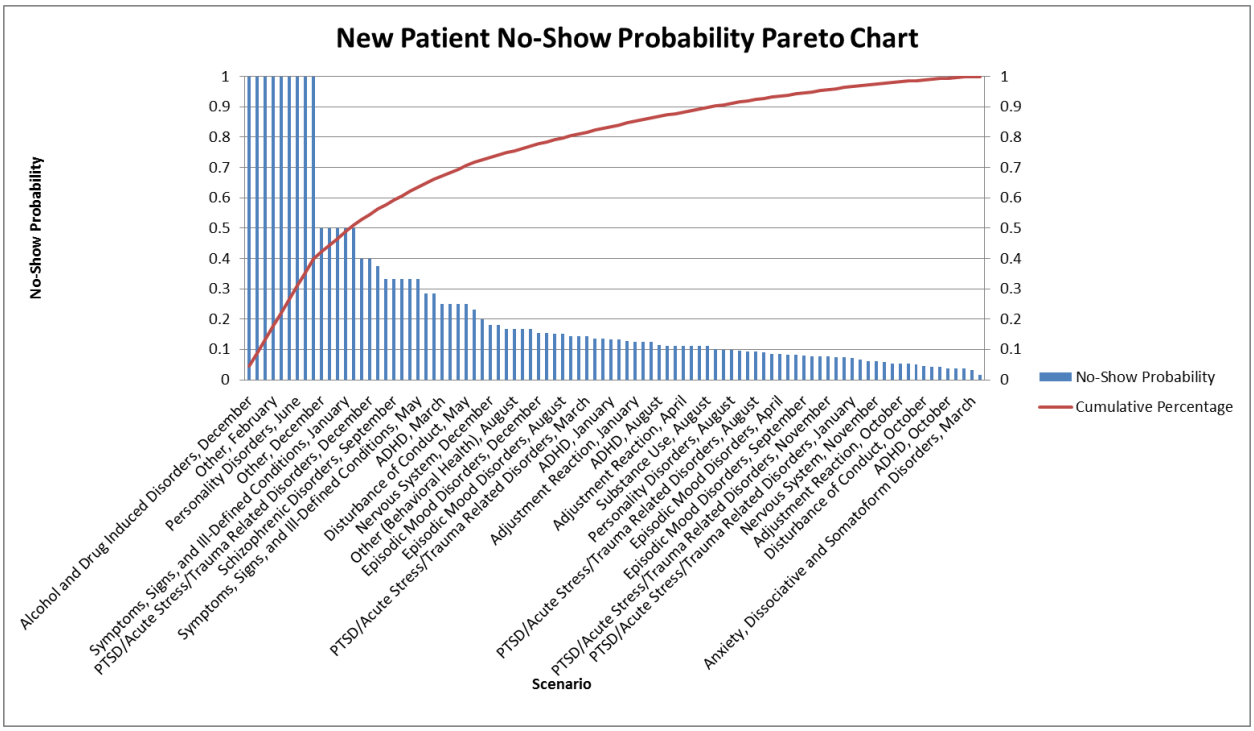


Figure A1. Pareto Chart of No-Show Probabilities for New Patient Scenarios

Table A3. New Patient Scenarios Accounting for 80% of Sum of No-Show Probabilities

ICD-9	Month	Probability of No-Show	No-Show Count	Total observations
ADHD	February	0.166666667	1	6
ADHD	March	0.25	1	4
ADHD	September	0.153846154	4	26
Adjustment Reaction	December	0.285714286	2	7
Adjustment Reaction	March	0.4	2	5
Alcohol and Drug Induced Disorders	December	1	1	1
Anxiety, Dissociative and Somatoform Disorders	August	0.143589744	28	195
Complications of Pregnancy, Childbirth, and the Puerperium	June	0.25	1	4
Complications of Pregnancy, Childbirth, and the Puerperium	May	1	2	2
Digestive System	August	0.25	1	4

Disturbance of Conduct	April	0.2	1	5
Disturbance of Conduct	August	0.230769231	6	26
Disturbance of Conduct	May	0.25	1	4
Episodic Mood Disorders	August	0.151624549	84	554
Episodic Mood Disorders	December	0.154761905	13	84
Episodic Mood Disorders	February	0.151898734	12	79
Injury and Poisoning	May	1	1	1
Nervous System	December	0.181818182	2	11
Other	December	0.5	1	2
Other	February	1	2	2
Other	January	0.5	1	2
Other (Behavioral Health)	August	0.166666667	1	6
Other (Behavioral Health)	February	1	2	2
Personality Disorders	December	1	1	1
Personality Disorders	June	1	1	1
Personality Disorders	October	0.5	1	2
Pervasive Developmental Disorders	August	0.166666667	1	6
PTSD/Acute Stress/Trauma Related Disorders	December	0.4	2	5
Schizophrenic Disorders	April	0.333333333	1	3
Schizophrenic Disorders	January	0.181818182	2	11
Schizophrenic Disorders	June	0.285714286	2	7
Schizophrenic Disorders	November	0.166666667	2	12
Schizophrenic Disorders	September	0.333333333	7	21
Substance Use	April	1	1	1
Substance Use	June	0.333333333	1	3
Substance Use	May	1	1	1
Substance Use	October	0.333333333	2	6
Symptoms, Signs, and Ill-Defined Conditions	August	0.375	3	8
Symptoms, Signs, and Ill-Defined Conditions	January	0.5	1	2
Symptoms, Signs, and Ill-Defined Conditions	May	0.333333333	1	3
Symptoms, Signs, and Ill-Defined Conditions	November	0.5	1	2

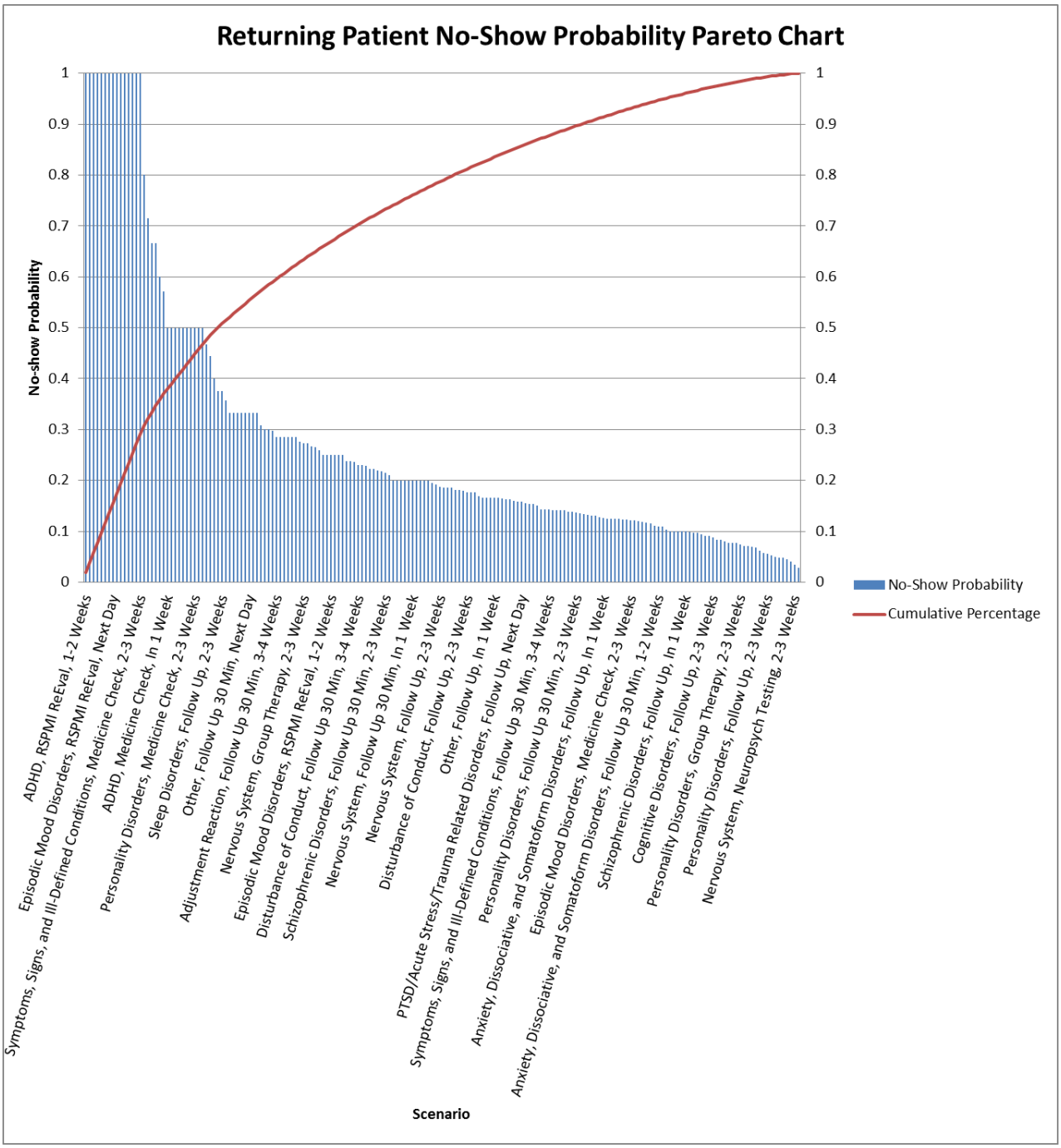


Figure A2. Pareto Chart of No-Show Probabilities for Returning Patient Scenarios

Table A4. Returning Patient Scenarios Accounting for 80% of Sum of No-Show Probabilities

ICD-9	Visit Type	Lead Time	Probability of No-Show	No-Show Count	Total observations
ADHD	Follow Up	1-2 Weeks	0.185185185	5	27
ADHD	Follow Up	2-3 Weeks	0.236842105	36	152
ADHD	Follow Up 30 Min	In 1 Week	0.275862069	8	29
ADHD	Follow Up 30 Min	Same Day	0.266666667	4	15
ADHD	Medicine Check	In 1 Week	0.5	1	2
ADHD	RSPMI ReEval	1-2 Weeks	1	1	1
Adjustment Reaction	Follow Up 30 Min	3-4 Weeks	0.285714286	4	14
Adjustment Reaction	Follow Up 30 Min	In 1 Week	0.2	1	5
Adjustment Reaction	RSPMI ReEval	2-3 Weeks	0.2	1	5
Alcohol and Drug Induced Disorders	Follow Up 30 Min	1-2 Weeks	1	1	1
Anxiety, Dissociative, and Somatoform Disorders	Follow Up 30 Min	Next Day	0.3	3	10
Anxiety, Dissociative, and Somatoform Disorders	Group Therapy	2-3 Weeks	0.714285714	10	14
Anxiety, Dissociative, and Somatoform Disorders	Group Therapy	3-4 Weeks	0.444444444	8	18
Anxiety, Dissociative, and Somatoform Disorders	Medicine Check	1-2 Weeks	0.2	1	5
Anxiety, Dissociative, and Somatoform Disorders	Medicine Check	3-4 Weeks	0.25	1	4
Anxiety, Dissociative, and Somatoform Disorders	Psychological Testing 120 Min	1-2 Weeks	1	1	1
Anxiety, Dissociative, and Somatoform Disorders	Psychological Testing 120 Min	In 1 Week	0.333333333	1	3
Anxiety, Dissociative, and Somatoform Disorders	RSPMI ReEval	1-2 Weeks	0.333333333	1	3
Anxiety, Dissociative, and Somatoform Disorders	RSPMI ReEval	2-3 Weeks	0.219512195	9	41
Anxiety, Dissociative, and Somatoform Disorders	RSPMI ReEval	3-4 Weeks	0.5	2	4
Cognitive Disorders	Neuropsych Testing	3-4 Weeks	0.333333333	1	3
Complications of Pregnancy, Childbirth, and the Puerperium	Follow Up	2-3 Weeks	0.466666667	7	15
Complications of Pregnancy, Childbirth, and the Puerperium	Follow Up 30 Min	In 1 Week	1	1	1

Disturbance of Conduct	Follow Up	1-2 Weeks	0.238095238	5	21
Disturbance of Conduct	Follow Up	In 1 Week	0.2	3	15
Disturbance of Conduct	Follow Up 30 Min	3-4 Weeks	0.230769231	6	26
Disturbance of Conduct	Group Therapy	2-3 Weeks	1	2	2
Disturbance of Conduct	RSPMI ReEval	2-3 Weeks	0.25	3	12
Eating Disorders	Follow Up 30 Min	In 1 Week	0.5	1	2
Eating Disorders	Group Therapy	1-2 Weeks	1	1	1
Eating Disorders	Group Therapy	In 1 Week	1	2	2
Episodic Mood Disorders	Follow Up 30 Min	2-3 Weeks	0.18583043	320	1722
Episodic Mood Disorders	Group Therapy	2-3 Weeks	0.266055046	87	327
Episodic Mood Disorders	Group Therapy	3-4 Weeks	0.307692308	4	13
Episodic Mood Disorders	Group Therapy	Same Day	0.333333333	1	3
Episodic Mood Disorders	Neuropsych Testing	1-2 Weeks	0.4	2	5
Episodic Mood Disorders	RSPMI ReEval	1-2 Weeks	0.25	3	12
Episodic Mood Disorders	RSPMI ReEval	2-3 Weeks	0.259259259	21	81
Episodic Mood Disorders	RSPMI ReEval	3-4 Weeks	0.357142857	5	14
Episodic Mood Disorders	RSPMI ReEval	Next Day	1	1	1
Injury and Poisoning	Follow Up	1-2 Weeks	0.5	1	2
Injury and Poisoning	Follow Up	2-3 Weeks	0.2	2	10
Injury and Poisoning	Follow Up 30 Min	In 1 Week	1	1	1
Injury and Poisoning	Follow Up 30 Min	Same Day	0.5	1	2
Nervous System	Follow Up	2-3 Weeks	0.1875	9	48
Nervous System	Follow Up	3-4 Weeks	0.285714286	4	14
Nervous System	Follow Up	Next Day	1	1	1
Nervous System	Follow Up 30 Min	1-2 Weeks	0.666666667	2	3
Nervous System	Follow Up 30 Min	In 1 Week	0.2	1	5
Nervous System	Group Therapy	2-3 Weeks	0.272727273	3	11

Other	Follow Up	Same Day	1	1	1
Other	Follow Up 30 Min	2-3 Weeks	0.3	3	10
Other	Follow Up 30 Min	In 1 Week	0.333333333	1	3
Other	Follow Up 30 Min	Next Day	0.333333333	1	3
Other	Group Therapy	2-3 Weeks	0.571428571	4	7
Other	Medicine Check	2-3 Weeks	0.5	1	2
Other (Behavioral Health)	Follow Up	1-2 Weeks	0.5	4	8
Other (Behavioral Health)	Follow Up	3-4 Weeks	0.285714286	2	7
Other (Behavioral Health)	Follow Up	In 1 Week	0.210526316	4	19
Other (Behavioral Health)	Follow Up	Next Day	0.333333333	1	3
Other (Behavioral Health)	Follow Up 30 Min	1-2 Weeks	0.666666667	2	3
Other (Behavioral Health)	Follow Up 30 Min	2-3 Weeks	0.230769231	6	26
Other (Behavioral Health)	Follow Up 30 Min	In 1 Week	0.6	3	5
Personality Disorders	Follow Up 30 Min	3-4 Weeks	0.285714286	2	7
Personality Disorders	Group Therapy	3-4 Weeks	0.222222222	2	9
Personality Disorders	Medicine Check	2-3 Weeks	0.5	1	2
Pervasive Developmental Disorders	Follow Up	1-2 Weeks	1	1	1
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	3-4 Weeks	0.186206897	27	145
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	In 1 Week	0.192307692	35	182
PTSD/Acute Stress/Trauma Related Disorders	Follow Up 30 Min	2-3 Weeks	0.217391304	35	161
PTSD/Acute Stress/Trauma Related Disorders	Follow Up 30 Min	3-4 Weeks	0.228571429	8	35
PTSD/Acute Stress/Trauma Related Disorders	Follow Up 30 Min	Next Day	0.5	4	8
PTSD/Acute Stress/Trauma Related Disorders	Follow Up 30 Min	Same Day	0.2	1	5
PTSD/Acute Stress/Trauma Related Disorders	Group Therapy	1-2 Weeks	0.285714286	2	7
PTSD/Acute Stress/Trauma Related Disorders	Group Therapy	2-3 Weeks	0.297520661	36	121
PTSD/Acute Stress/Trauma Related Disorders	Group Therapy	3-4 Weeks	0.333333333	4	12
PTSD/Acute Stress/Trauma Related Disorders	Group Therapy	In 1 Week	0.2	1	5

Schizophrenic Disorders	Follow Up	2-3 Weeks	0.238095238	15	63
Schizophrenic Disorders	Follow Up	3-4 Weeks	0.222222222	2	9
Schizophrenic Disorders	Follow Up 30 Min	1-2 Weeks	0.375	3	8
Schizophrenic Disorders	Follow Up 30 Min	2-3 Weeks	0.214876033	26	121
Schizophrenic Disorders	Follow Up 30 Min	3-4 Weeks	0.2	3	15
Schizophrenic Disorders	Follow Up 30 Min	Next Day	0.25	1	4
Schizophrenic Disorders	RSPMI ReEval	2-3 Weeks	0.2	1	5
Sleep Disorders	Follow Up	2-3 Weeks	0.375	3	8
Sleep Disorders	Follow Up 30 Min	3-4 Weeks	0.5	1	2
Substance Use	Follow Up	2-3 Weeks	0.195121951	8	41
Substance Use	Follow Up 30 Min	In 1 Week	0.25	1	4
Symptoms, Signs, and Ill-Defined Conditions	Follow Up	3-4 Weeks	0.25	1	4
Symptoms, Signs, and Ill-Defined Conditions	Follow Up 30 Min	2-3 Weeks	0.272727273	6	22
Symptoms, Signs, and Ill-Defined Conditions	Follow Up 30 Min	Same Day	0.285714286	2	7
Symptoms, Signs, and Ill-Defined Conditions	Group Therapy	1-2 Weeks	1	1	1
Symptoms, Signs, and Ill-Defined Conditions	Group Therapy	2-3 Weeks	0.8	4	5
Symptoms, Signs, and Ill-Defined Conditions	Group Therapy	In 1 Week	1	1	1
Symptoms, Signs, and Ill-Defined Conditions	Medicine Check	2-3 Weeks	1	1	1

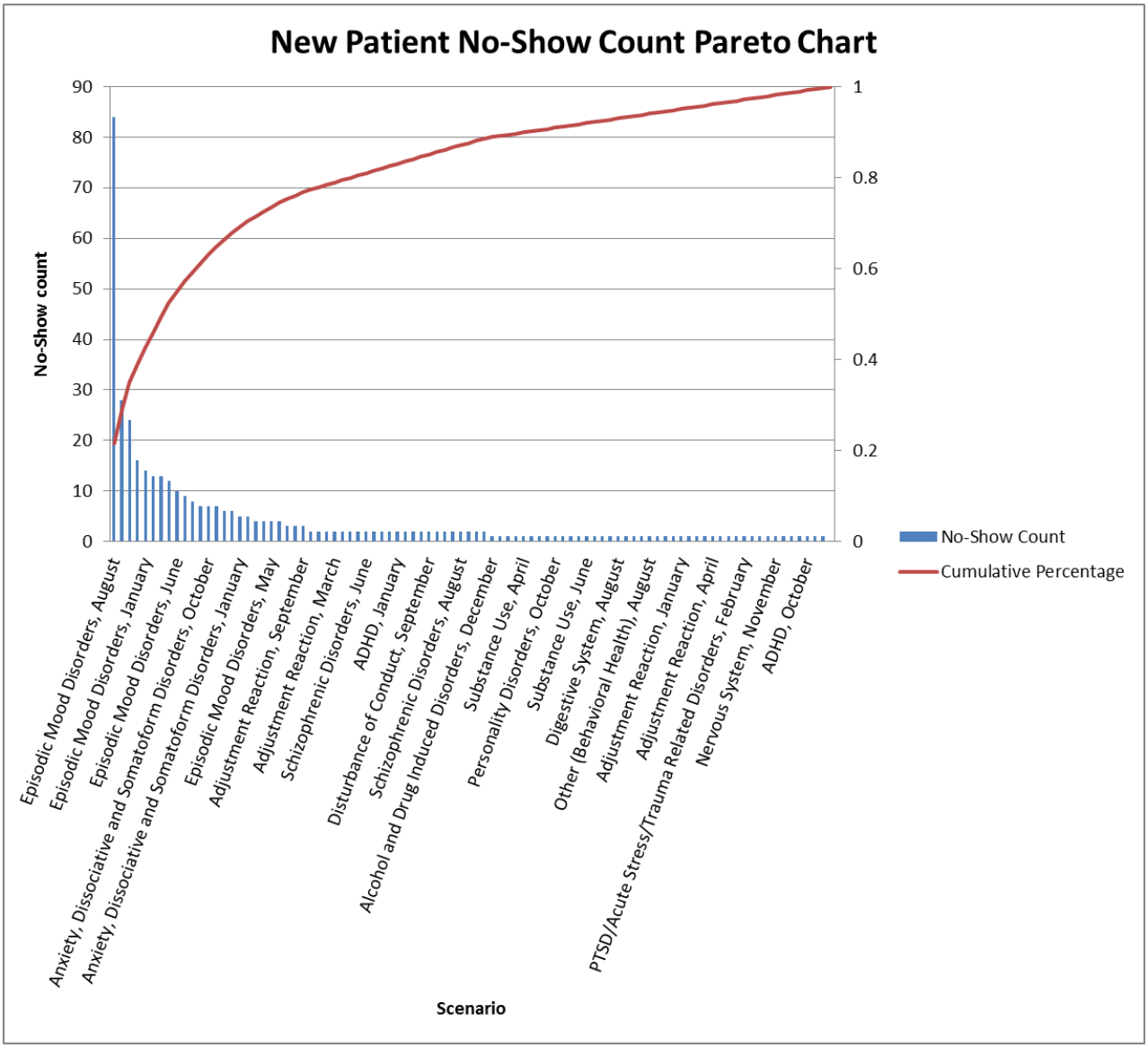


Figure A3. Pareto Chart of No-Show Count for New Patient Scenarios

Table A5. New Patient Scenarios Accounting for 80% of No-Shows

ICD-9	Month	Probability of No-Show	No-Show Count	Total observations
ADHD	August	0.115384615	6	52
ADHD	September	0.153846154	4	26
Adjustment Reaction	September	0.096774194	3	31
Anxiety, Dissociative and Somatoform Disorders	April	0.133333333	4	30

Anxiety, Dissociative and Somatoform Disorders	August	0.143589744	28	195
Anxiety, Dissociative and Somatoform Disorders	January	0.135135135	5	37
Anxiety, Dissociative and Somatoform Disorders	October	0.086419753	7	81
Anxiety, Dissociative and Somatoform Disorders	September	0.081818182	9	110
Disturbance of Conduct	August	0.230769231	6	26
Episodic Mood Disorders	April	0.086419753	7	81
Episodic Mood Disorders	August	0.151624549	84	554
Episodic Mood Disorders	December	0.154761905	13	84
Episodic Mood Disorders	February	0.151898734	12	79
Episodic Mood Disorders	January	0.127272727	14	110
Episodic Mood Disorders	July	0.043478261	4	92
Episodic Mood Disorders	June	0.112359551	10	89
Episodic Mood Disorders	March	0.094117647	8	85
Episodic Mood Disorders	May	0.043956044	4	91
Episodic Mood Disorders	November	0.100628931	16	159
Episodic Mood Disorders	October	0.053061224	13	245
Episodic Mood Disorders	September	0.080536913	24	298
PTSD/Acute Stress/Trauma Related Disorders	August	0.092592593	5	54
PTSD/Acute Stress/Trauma Related Disorders	September	0.136363636	3	22
Schizophrenic Disorders	September	0.333333333	7	21
Symptoms, Signs, and Ill-Defined Conditions	August	0.375	3	8

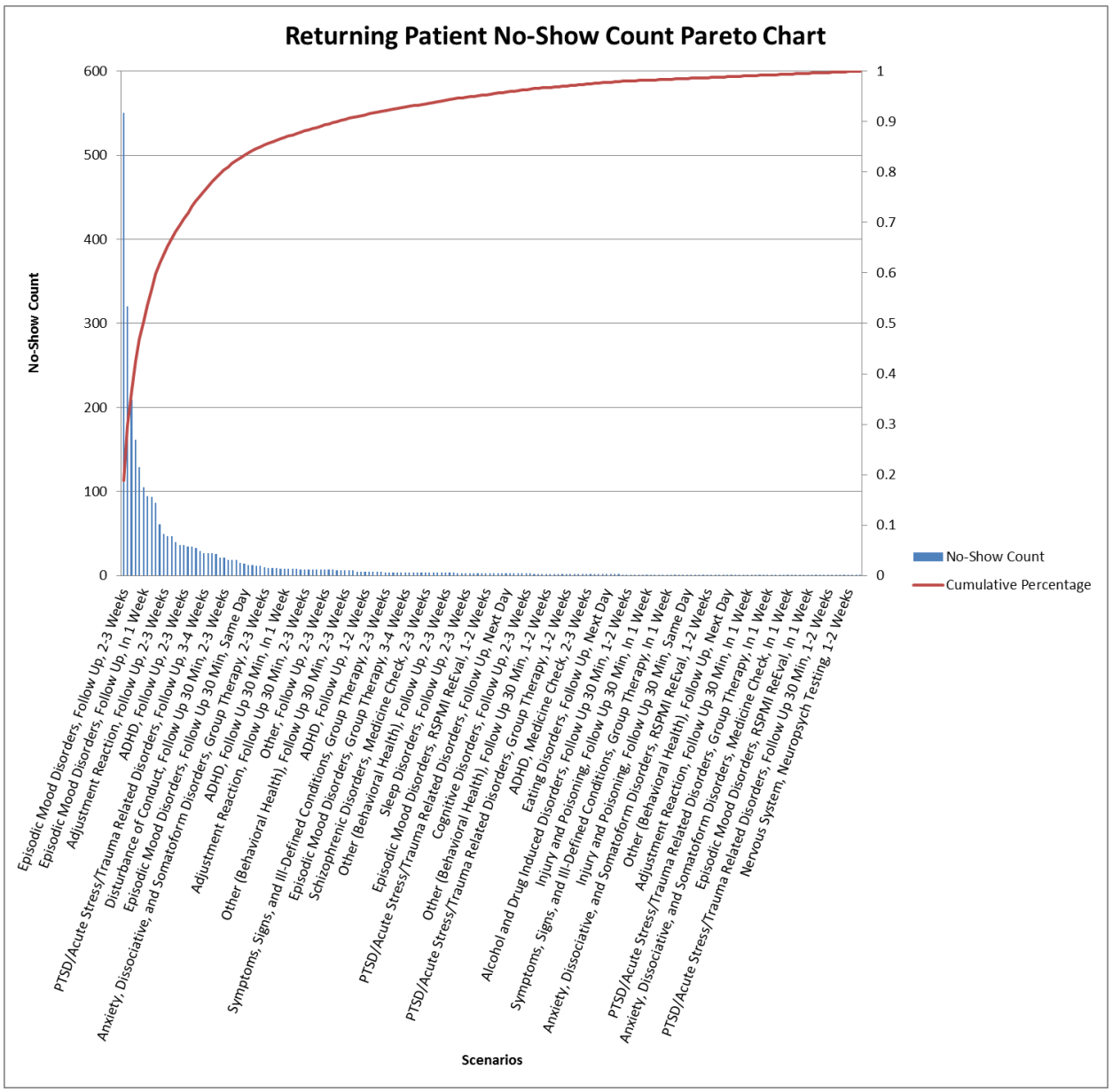


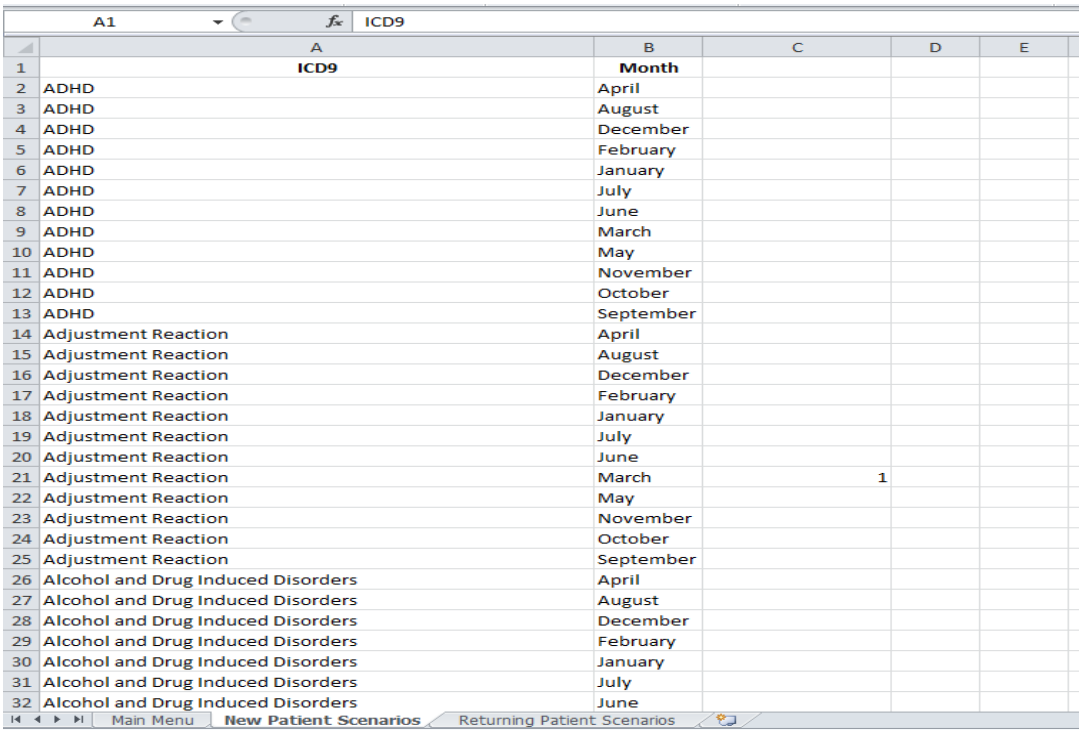
Figure A4. Pareto Chart of No-Show Count for Returning Patient Scenarios

Table A6. Returning Patient Scenarios Accounting for 80% of No-Shows

ICD-9	Visit Type	Lead Time	Probability of No-Show	No-Show Count	Total observations
ADHD	Follow Up	2-3 Weeks	0.236842105	36	152
ADHD	Follow Up 30 Min	2-3 Weeks	0.133027523	29	218

Adjustment Reaction	Follow Up	2-3 Weeks	0.123152709	50	406
Anxiety, Dissociative, and Somatoform Disorders	Follow Up	1-2 Weeks	0.133333333	40	300
Anxiety, Dissociative, and Somatoform Disorders	Follow Up	2-3 Weeks	0.123303835	209	1695
Anxiety, Dissociative, and Somatoform Disorders	Follow Up	3-4 Weeks	0.117794486	47	399
Anxiety, Dissociative, and Somatoform Disorders	Follow Up	In 1 Week	0.126684636	47	371
Anxiety, Dissociative, and Somatoform Disorders	Follow Up 30 Min	2-3 Weeks	0.140949555	95	674
Disturbance of Conduct	Follow Up 30 Min	2-3 Weeks	0.154411765	21	136
Episodic Mood Disorders	Follow Up	1-2 Weeks	0.150174622	129	859
Episodic Mood Disorders	Follow Up	2-3 Weeks	0.143640637	550	3829
Episodic Mood Disorders	Follow Up	3-4 Weeks	0.140992167	162	1149
Episodic Mood Disorders	Follow Up	In 1 Week	0.119318182	105	880
Episodic Mood Disorders	Follow Up 30 Min	2-3 Weeks	0.18583043	320	1722
Episodic Mood Disorders	Follow Up 30 Min	3-4 Weeks	0.164864865	61	370
Episodic Mood Disorders	Follow Up 30 Min	In 1 Week	0.168367347	33	196
Episodic Mood Disorders	Group Therapy	2-3 Weeks	0.266055046	87	327
Episodic Mood Disorders	Medicine Check	2-3 Weeks	0.122171946	27	221
Episodic Mood Disorders	RSPMI ReEval	2-3 Weeks	0.259259259	21	81
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	1-2 Weeks	0.176470588	27	153
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	2-3 Weeks	0.157983193	94	595
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	3-4 Weeks	0.186206897	27	145
PTSD/Acute Stress/Trauma Related Disorders	Follow Up	In 1 Week	0.192307692	35	182
PTSD/Acute Stress/Trauma Related Disorders	Follow Up 30 Min	2-3 Weeks	0.217391304	35	161
PTSD/Acute Stress/Trauma Related Disorders	Group Therapy	2-3 Weeks	0.297520661	36	121
Schizophrenic Disorders	Follow Up 30 Min	2-3 Weeks	0.214876033	26	121

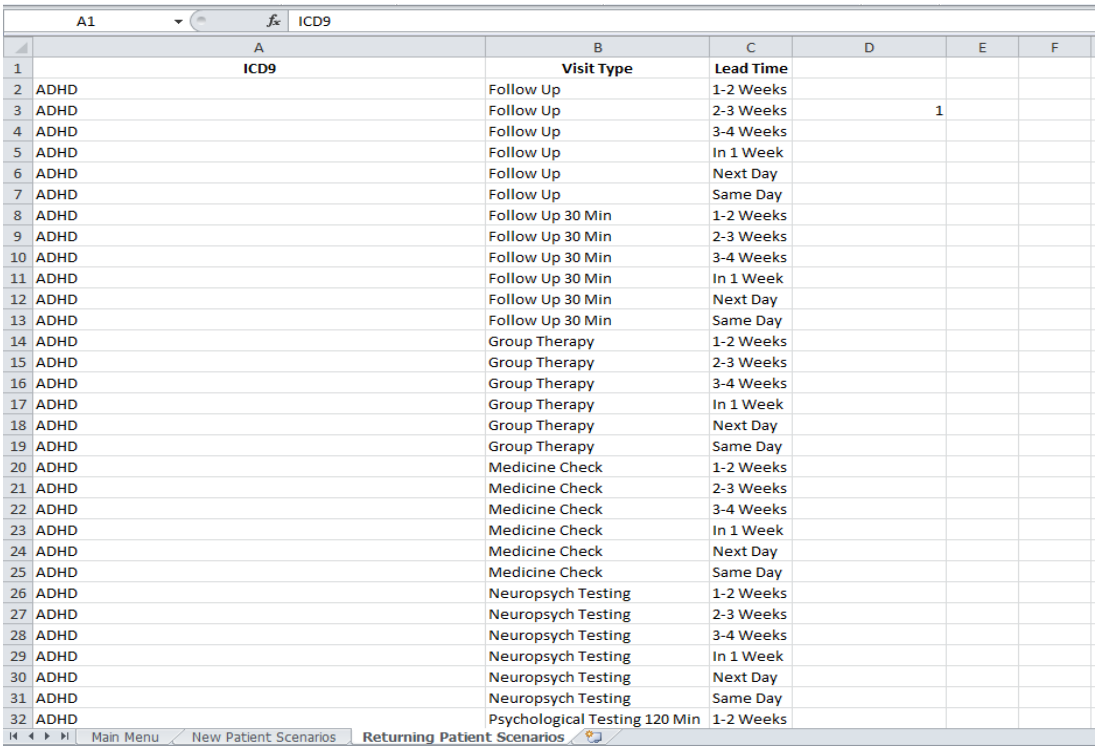
Appendix C: VBA Code for Decision Support Tool



	A	B	C	D	E
1	ICD9	Month			
2	ADHD	April			
3	ADHD	August			
4	ADHD	December			
5	ADHD	February			
6	ADHD	January			
7	ADHD	July			
8	ADHD	June			
9	ADHD	March			
10	ADHD	May			
11	ADHD	November			
12	ADHD	October			
13	ADHD	September			
14	Adjustment Reaction	April			
15	Adjustment Reaction	August			
16	Adjustment Reaction	December			
17	Adjustment Reaction	February			
18	Adjustment Reaction	January			
19	Adjustment Reaction	July			
20	Adjustment Reaction	June			
21	Adjustment Reaction	March	1		
22	Adjustment Reaction	May			
23	Adjustment Reaction	November			
24	Adjustment Reaction	October			
25	Adjustment Reaction	September			
26	Alcohol and Drug Induced Disorders	April			
27	Alcohol and Drug Induced Disorders	August			
28	Alcohol and Drug Induced Disorders	December			
29	Alcohol and Drug Induced Disorders	February			
30	Alcohol and Drug Induced Disorders	January			
31	Alcohol and Drug Induced Disorders	July			
32	Alcohol and Drug Induced Disorders	June			

Main Menu | New Patient Scenarios | Returning Patient Scenarios

Figure A5. New Patient Scenarios Hidden Worksheet



	A	B	C	D	E	F
1	ICD9	Visit Type	Lead Time			
2	ADHD	Follow Up	1-2 Weeks			
3	ADHD	Follow Up	2-3 Weeks	1		
4	ADHD	Follow Up	3-4 Weeks			
5	ADHD	Follow Up	In 1 Week			
6	ADHD	Follow Up	Next Day			
7	ADHD	Follow Up	Same Day			
8	ADHD	Follow Up 30 Min	1-2 Weeks			
9	ADHD	Follow Up 30 Min	2-3 Weeks			
10	ADHD	Follow Up 30 Min	3-4 Weeks			
11	ADHD	Follow Up 30 Min	In 1 Week			
12	ADHD	Follow Up 30 Min	Next Day			
13	ADHD	Follow Up 30 Min	Same Day			
14	ADHD	Group Therapy	1-2 Weeks			
15	ADHD	Group Therapy	2-3 Weeks			
16	ADHD	Group Therapy	3-4 Weeks			
17	ADHD	Group Therapy	In 1 Week			
18	ADHD	Group Therapy	Next Day			
19	ADHD	Group Therapy	Same Day			
20	ADHD	Medicine Check	1-2 Weeks			
21	ADHD	Medicine Check	2-3 Weeks			
22	ADHD	Medicine Check	3-4 Weeks			
23	ADHD	Medicine Check	In 1 Week			
24	ADHD	Medicine Check	Next Day			
25	ADHD	Medicine Check	Same Day			
26	ADHD	Neuropsych Testing	1-2 Weeks			
27	ADHD	Neuropsych Testing	2-3 Weeks			
28	ADHD	Neuropsych Testing	3-4 Weeks			
29	ADHD	Neuropsych Testing	In 1 Week			
30	ADHD	Neuropsych Testing	Next Day			
31	ADHD	Neuropsych Testing	Same Day			
32	ADHD	Psychological Testing 120 Min	1-2 Weeks			

Main Menu | New Patient Scenarios | Returning Patient Scenarios

Figure A6. Returning Patient Scenarios Hidden Worksheet

Module 1:

```
Option Explicit

'Define Variables
Public flag As Boolean
Public NumMonth As Double
Public Month As String
Public ICD-9 As String
Public AppointmentDate As Date
Public ScheduledDate As Date
Public NumLeadTime As Double
Public LeadTime As String
Public NewPatient As Boolean
Public VisitType As String
Public Day As String
Public HighNoShow As Boolean
Public i As Integer

Sub HideSheets()

'Hide probability worksheets
ActiveWorkbook.Worksheets("New Patient Scenarios").Visible = False
ActiveWorkbook.Worksheets("Returning Patient Scenarios").Visible = False

End Sub

Sub NewPatientVariables()

'month variable
NumMonth = DatePart("m", AppointmentDate)

If NumMonth = 1 Then

   Month = "January"

ElseIf NumMonth = 2 Then

   Month = "February"

ElseIf NumMonth = 3 Then

   Month = "March"

ElseIf NumMonth = 4 Then

   Month = "April"

ElseIf NumMonth = 5 Then

   Month = "May"

ElseIf NumMonth = 6 Then
```

```
   Month = "June"
ElseIf NumMonth = 7 Then
   Month = "July"
ElseIf NumMonth = 8 Then
   Month = "August"
ElseIf NumMonth = 9 Then
   Month = "September"
ElseIf NumMonth = 10 Then
   Month = "October"
ElseIf NumMonth = 11 Then
   Month = "November"
ElseIf NumMonth = 12 Then
   Month = "December"
End If
End Sub
Sub ReturningPatientVariables()
'lead time variable
NumLeadTime = DateDiff("d", ScheduledDate, AppointmentDate)
If NumLeadTime = 0 Then
   LeadTime = "Same Day"
ElseIf NumLeadTime = 1 Then
   LeadTime = "Next Day"
ElseIf NumLeadTime < 8 Then
   LeadTime = "In 1 Week"
ElseIf NumLeadTime < 15 Then
   LeadTime = "1-2 Weeks"
ElseIf NumLeadTime < 22 Then
   LeadTime = "2-3 Weeks"
```

```
ElseIf NumLeadTime < 28 Then

   LeadTime = "3-4 Weeks"

Else

   LeadTime = "Over 4 Weeks"

End If

End Sub

Sub NewPatients()

'Retrieve new patient variables
Call NewPatientVariables

'Find recommendation category
For i = 2 To 397

If ActiveWorkbook.Worksheets("New Patient Scenarios").Cells(i, 1).Value = ICD-9 Then

   If ActiveWorkbook.Worksheets("New Patient Scenarios").Cells(i, 2).Value = Month Then

      If ActiveWorkbook.Worksheets("New Patient Scenarios").Cells(i, 3).Value = 1 Then

         HighNoShow = True

      Else

         HighNoShow = False

      End If

   End If

End If

Next i

End Sub

Sub ReturningPatients()

'Retrieve returning patient variables
Call ReturningPatientVariables

   'Find recommendation category
   For i = 2 To 1585

      If ActiveWorkbook.Worksheets("Returning Patient Scenarios").Cells(i, 1).Value = ICD-9 Then

         If ActiveWorkbook.Worksheets("Returning Patient Scenarios").Cells(i, 2).Value = VisitType Then
```

```
            If ActiveWorkbook.Worksheets("Returning Patient Scenarios").Cells(i, 3).Value = LeadTime Then

              If ActiveWorkbook.Worksheets("Returning Patient Scenarios").Cells(i, 4).Value = 1 Then

                HighNoShow = True

              Else

                HighNoShow = False

              End If

            End If

          End If

        End If

    Next i

End Sub

Sub Start()

flag = False

'Open Welcome Form
frmWelcome.Show

'if cancel is not pressed
If flag = True Then

    'Call new patient or returning patient sub
    If NewPatient = True Then

      Call NewPatients

    Else

      Call ReturningPatients

    End If
      'Check lead time
    If (NewPatient = False And LeadTime = "Over 4 Weeks") Then

      MsgBox "The lead time for this appointment is too long to predict the risk of no-show."

    Else

      'Make recommendation based on category
      If HighNoShow = True Then

        MsgBox "Based on past data, there is a high chance this patient will not show up for his/her
appointment. Alternative methods of scheduling such as overbooking or open-access are recommended for
this patient."
```

```
    Else

      MsgBox "Based on past data, there is a low chance this patient will not show up for his/her
appointment.  Fixed scheduling is recommended for this patient."

    End If

  End If

End If

End Sub

Sub Instructions()

'Open Instructions form
frmInstructions.Show

End Sub
```

Welcome User Form:

```
Private Sub cmdCancel_Click()

Unload Me

End Sub

Private Sub cmdContinue_Click()

Unload Me

'show new patient user form
frmNewPatient.Show

End Sub
```

NewPatient User Form:

```
Private Sub cmdCancel_Click()

Unload Me

End Sub

Private Sub cmdNewPatient_Click()
```

```
'Set NewPatient variable as new patient
NewPatient = True

Unload Me

'show ICD-9 user form
frmICD-9.Show

End Sub

Private Sub cmdReturningPatient_Click()

'Set NewPatient variable as returning patient
NewPatient = False

Unload Me

'show ICD-9 user form
frmICD-9.Show

End Sub
```

ICD-9 User Form:

```
Private Sub cmdCancel_Click()

Unload Me

End Sub

Private Sub UserForm_Initialize()

'initialize the combo box
cbICD-9.AddItem "ADHD"
cbICD-9.AddItem "Adjustment Reaction"
cbICD-9.AddItem "Alcohol and Drug Induced Disorders"
cbICD-9.AddItem "Anxiety, Dissociative and Somatoform Disorders"
cbICD-9.AddItem "Blood and Blood-Forming Organs"
cbICD-9.AddItem "Certain Conditions Origination in the Perinatal Period"
cbICD-9.AddItem "Circulatory System"
cbICD-9.AddItem "Cognitive Disorders"
cbICD-9.AddItem "Complications of Pregnancy, Childbirth, and the Puerperium"
cbICD-9.AddItem "Congenital Anomalies"
cbICD-9.AddItem "Digestive System"
cbICD-9.AddItem "Disturbance of Conduct"
cbICD-9.AddItem "Eating Disorders"
cbICD-9.AddItem "Endocrine, Nutritional, Metabolic and Immunity Disorders"
cbICD-9.AddItem "Episodic Mood Disorders"
cbICD-9.AddItem "External Causes of Injury and Supplemental Classification"
cbICD-9.AddItem "Genitourinary System"
cbICD-9.AddItem "Injury and Poisoning"
cbICD-9.AddItem "Mental Retardation"
cbICD-9.AddItem "Musculoskeletal System and Connective Tissue"
cbICD-9.AddItem "Neoplasms"
```

```
cbICD-9.AddItem "Nervous System"
cbICD-9.AddItem "Other"
cbICD-9.AddItem "Other (Behavioral Health)"
cbICD-9.AddItem "Personality Disorders"
cbICD-9.AddItem "Pervasive Developmental Disorders"
cbICD-9.AddItem "PTSD/Acute Stress/Trauma Related Disorders"
cbICD-9.AddItem "Respiratory System"
cbICD-9.AddItem "Schizophrenic Disorders"
cbICD-9.AddItem "Sexual and Gender Identity Disorders"
cbICD-9.AddItem "Sleep Disorders"
cbICD-9.AddItem "Specific Delays in Development"
cbICD-9.AddItem "Specific Nonpsychotic Disorders Due to Brain Damage"
cbICD-9.AddItem "Substance Use"
cbICD-9.AddItem "Symptoms, Signs, and Ill-Defined Conditions"
cbICD-9.AddItem "Tic Disorders"

End Sub

Private Sub cmdNext_Click()

'if a ICD-9 is not selected
If cbICD-9.Value = "" Then

   MsgBox "Please select an ICD-9 value for this patient."

Else

   'Set ICD-9 variable to input ICD-9
   ICD-9 = cbICD-9.Value

   Unload Me

   'if new patient
   If NewPatient = True Then

      'open user form insurance type
      frmDates.Show

   Else

      'open user form visit type
      frmVisitType.Show

   End If

End If

End Sub
```

VisitType User Form:

```
Private Sub cmdCancel_Click()

Unload Me
```

```
End Sub

Private Sub UserForm_Initialize()

cbVisitType.AddItem "Follow Up"
cbVisitType.AddItem "Follow Up 30 Min"
cbVisitType.AddItem "Group Therapy"
cbVisitType.AddItem "Medicine Check"
cbVisitType.AddItem "Neuropsych Testing"
cbVisitType.AddItem "New Patient"
cbVisitType.AddItem "Psychological Testing 120 Min"
cbVisitType.AddItem "Psychological Testing 60 Min"
cbVisitType.AddItem "RSPMI ReEval"

End Sub

Private Sub cmdNext_Click()

'if a visit type is not selected
If cbVisitType.Value = "" Then

   MsgBox "Please select a visit type for this patient."

Else

   'Set VisitType variable as input visit type
   VisitType = cbVisitType.Value

   Unload Me

   'open user form dates
   frmDates.Show

End If

End Sub
```

Dates User Form:

```
Private Sub cmdCancel_Click()

Unload Me

End Sub

Private Sub cmdNext_Click()

'if date value is entered into the text boxes
If (IsDate(tbAppointmentDate.Value) And IsDate(tbScheduledDate.Value)) Then

   'check that appointment date is later than scheduled date
   If (CDate(tbAppointmentDate.Value) >= CDate(tbScheduledDate.Value)) Then
```

```
        'set date variables
        AppointmentDate = CDate(tbAppointmentDate.Value)
        ScheduledDate = CDate(tbScheduledDate.Value)

        'Set flag to true
        flag = True

        Unload Me

    Else

        MsgBox "Date of appointment must be later than date scheduled."

    End If

'if date value is not entered into the text boxes
Else

    MsgBox "Please enter dates in the form of mm/dd/yyyy."

End If

End Sub
```

Instructions User Form:

```
Private Sub cmdOK_Click()

Unload Me

End Sub
```